Construction Air Quality Assessment
Yonge Subway Extension
Train Storage and Maintenance Facility
Toronto, Ontario

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1.0 Introduction

Novus Environmental Inc. (Novus) was retained by McCormick Rankin (MRC), a member of MMM Group, to assess the potential for air quality impacts from construction of the proposed Train Storage and Maintenance Facility (TSF), which is part of the proposed Yonge Street Subway Extension project.

In 2009-2010, the TTC undertook a review of the subway rail yard needs for the Yonge Subway to the year 2030. It was determined that the car fleet would grow from 62 trains to a total of 88 trains. The implication for the Yonge Subway Extension is the need for a train storage facility in the area of Richmond Hill Centre.

Primary maintenance for the Yonge Subway Extension will continue to be at the Wilson Yard located south of Downsview Station. However, overnight train storage will be provided in the area of Richmond Hill Centre Station and within an underground TSF where light-duty maintenance and cleaning of the subway vehicles will occur.

Several alternatives were developed for the storage facility including options which extended under Yonge Street north of the Langstaff Station, under the Commuter Parking Lot within the hydro corridor and extending easterly within the hydro corridor north of Highway 7. Several alternatives were also developed which extended the subway line north of Richmond Hill Centre Station. Based on a high-level screening, a preferred alternative was selected.

2.0 Study Objectives

Novus Environmental Inc. was retained by McCormick Rankin (MRC), a member of MMM Group, to assess the potential air quality impacts related to the proposed construction of the TSF north of the Richmond Hill Centre station. The facility is proposed to be approximately 800 meters long, and will be approximately 20 meters below grade.

The objectives of this study are as follows:

- to identify the primary areas of concern due to construction activities in the corridor;
- to estimate emission rates of the selected contaminants based on the types of construction activities;
- to predict the concentrations of selected contaminants resulting from the construction activities on adjacent sensitive land uses;
- to assess the relative change in potential impacts based on the pre-mitigation and post-mitigation predictions; and
- to make recommendations for mitigation, if warranted.

It should be noted that this is an assessment of the potential impacts during the construction period, and a comparison between pre and post construction impacts was not performed.

3.0 Contaminants of Concern

The contaminants of interest from construction and demolition activities include particulate matter (PM), carbon dioxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and volatile organic compounds (VOCs). Considering that emissions of CO, NO_2, SO_2 and VOCs are primarily related to the combustion of fuels used by construction equipment, it is recommended that a construction code of practice such as Environment Canada's "Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities" (2005) be implemented for these emission sources. Common best practices for these emission sources include reformulated fuels, emulsified fuels, catalysts and filtration technologies, and cleaner engine repowers. Therefore, this study will focus on the prediction and mitigation of PM/dust emissions which are related to a number of emissions sources and are highly dependent on the location and types of construction activities being undertaken. Specifically, total suspended particulate matter (TSP) will be studied, which is defined as particles with a diameter of less than 44 microns in size.

4.0 Areas of Concern

Construction air quality impacts will primarily occur where exposed construction activities are conducted. The areas where exposed construction activities are anticipated to occur in the study area are identified in **Figure 1**. The construction area includes the train storage and maintenance facility and associated structures, covering a total area of approximately 16,000 m^2.

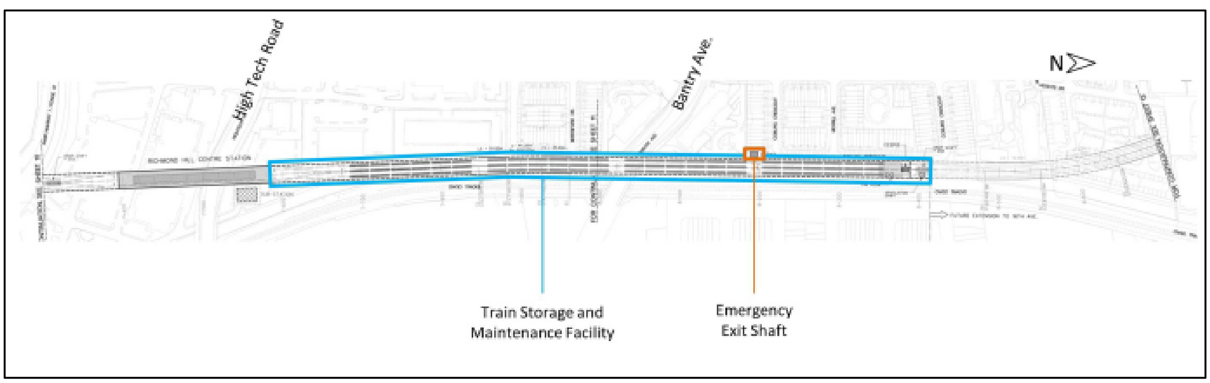

Figure 1: Layout and Location of Exposed Construction Activities

The area surrounding the exposed construction activities are bounded by a mixture of commercial and residential land uses. Land uses which are defined as sensitive receptors for evaluating air quality effects are:

- Health care facilities;
- Senior citizen long-term care facilities;
- Child care facilities;
- Educational facilities;
- Places of worship; and
- Residential dwellings.

The worst-case sensitive receptor is shown relative to the exposed construction activities in **Figure 2** and was used as representative of potential impacts for this study, as impacts at sensitive receptors further from the activities will be lower.

Figure 2: Location of Worst-Case Sensitive Receptors within the Study Area

5.0 Anticipated Construction Methods

For modelling purposes, the construction methods studied in this report were broken down into several distinct stages and analyzed separately. Construction methods and timing will vary between the separate components of the site due to the requirements of each structure. The construction methods used at each location are summarized in **Table 1**. The individual construction methods discussed in this table are described further in this section.

Table 1: Summary of Construction Methods Used at each Location

Area	Pavement Removal	Soldier Pile Drilling	Overburden Excavation	Pipe Pile Drilling	Decking Installation	Continuing Excavation
Train Storage and Maintenance Facility	X	X	X	X	X	X
Emergency Exit Shaft	X	X	X	X	X	X

For all steps of construction, the rate at which activities will progress was provided by MRC. The following construction details were provided by MRC and were used in this assessment:

- A maximum of 15 haul trucks per hour on-site;

- A pipe and soldier piles installation rate of 2 hours per pile; and
- A material removal rate of 1500 m^3 per 8-hour day

The individual steps of construction analyzed in this report are discussed in **Table 2**. For each process, emissions were calculated based on the individual dust generation rates for material processing, diesel emissions from the equipment, and fugitive emissions from equipment on the roadways.

Table 2: Description of Construction Methods

Construction Method	Description
Pavement Removal	Initially, the removal of the roadway and sidewalk pavement (hardscraping) will commence. Pavement will be demolished into workable pieces and transported off-site using haul trucks, backhoes, pavement breakers, saws, or other similar equipment.
Soldier Pile Drilling	Prior to excavation, soldier piles will be drilled to support the sides of the excavation. Drilled piles will be used.
Overburden Excavation	Before decking can be laid, a sufficient depth of material must be removed in order to make room for the decking while allowing construction crews access to the ground underneath. Overburden will be removed using bulldozers or diggers. Removed material will be transported off-site using haul trucks.
Pipe Pile Drilling	Pipe piles will be used to support the decking while the tunnel is constructed. This phase will involve all the same processes as soldier pile drilling except that additional pipe piles will be drilled. It is assumed that drilling will progress at the same rate as for soldier piles.
Installation of Decking	With the supporting piles up, decking will be installed over the majority of the excavation. A portion of the site will be left open to the surface to allow construction equipment and materials in and out of the excavation. Pre-cast decking will be transported on site and laid using lifting equipment such as a crane.
Continuing Excavation	Once decking has been installed, excavation and construction will continue below the deck. This will likely be the longest phase of construction and primary emissions will come from the transportation of materials off-site via haul trucks.

6.0 Assessment Approach

In order to estimate the worst-case dust impacts resulting from the various phases of construction:

- emission rates were estimated based on U.S. EPA and Environment Canada published values;
- air dispersion modelling was conducted; and
- mitigation measures were recommended, if warranted.

6.1 Applicable Guidelines

There are no regulated exposure limits for dust generated due to construction activities within the Province of Ontario due to the inevitable nature and short-term duration of such emissions.

Therefore, the evaluation focused on assessing the relative change between pre-mitigation and post-mitigation maximum ground-level concentrations during construction activities as predicted by the dispersion model. It should be noted that for TSP emissions from provincially regulated sources, a point of impingement limit of 120 $\mu g/m^3$ based on a 24-hour averaging period is used to determine compliance. This guideline is not applicable to construction activities and has not been applied in this assessment.

6.2 Emission Rates

Emissions rates were estimated using appropriate published values for similar activities. Emissions were generated for on-site activities including: construction vehicle tailpipe emissions, fugitive emissions from the roadways, and the dust generated from material processing (e.g. pavement breaking). Material processing and roadway fugitive emission rates were estimated based on the United States (U.S.) Environmental Protection Agency (EPA) AP-42 chapter 11.9 “Western Surface Coal Mining” (1998), chapter 13.2.4 “Aggregate Handling and Storage Piles” (2006) and chapter 13.2.1 “Paved Roads” (2011), as well as the Environment Canada “Pits and Quarries Guidance” document. Vehicle emissions were estimated using the emission ratings from diesel engines of typical construction vehicles (Road Construction, Caterpillar).

It is important to note that all of the above documents provide emission rates for total suspended particulates (TSP) with diameter < 30 µm which is defined in U.S. EPA AP-42. In Ontario TSP is based on a defined particle size < 44 µm. Note that in this report, TSP refers to TSP < 44 µm in size, unless otherwise specified.

For consistency with the Ontario standards, the TSP emissions were scaled from the 30 µm size definition to 44 µm. This was accomplished by comparing the measured silt loading size fractions based on core sampling conducted by Coffey Geotechnics for the Eglinton Light Rail project. It was assumed that due to the relatively close proximity, the soil properties would be representative of the study area. Based on that data, an average emissions increase of approximately 5-10% can be expected when converting from TSP < 30 µm to TSP < 44 µm. To account for this, the calculated emission rates for the model were increased by a conservative 10% to convert to TSP < 44 µm.

The entire area surrounding the site was assessed for impacts. The extents of these impacts is evaluated in **Section 7.0**. Details of the receptor grid modelled are discussed in **Section 5**.

Ground-level impacts surrounding the construction areas were estimated using the latest AERMOD dispersion model (U.S. EPA version 12060, Lakes AERMOD View version 8.0.5). The model uses local meteorology, terrain and emission rates to predict the impacts of specific contaminants at user-specified receptors. It should be noted that building effects are not considered by the AERMOD model when assessing area sources such as roadways and construction site, and therefore were not included in this study. Ground-level concentrations were assessed in order to determine appropriate mitigation methods required in order to reasonably minimize the impacts from construction activities.

Worst-case emission rates were predicted for the construction area. Given the proximity of the emergency exit shaft, it was assumed that excavation for the shaft would occur at the same stage as the cut and cover construction for the storage facility. The process-based TSP emission rates for construction are shown in **Table 3**.

Table 3: Construction Emission Rates

Construction Phase	Material Processing Emissions (g/s)	Roadway Fugitive Emissions (g/s)	Vehicle Emissions (g/s)	Total Emissions (g/s)
Pavement Removal	1.50	1.04	0.99	3.53
Soldier Piles Installation	0.09	1.31	1.03	2.43
Overburden Excavation	1.51	0.84	1.00	3.35

6.3 Modelling Methods

In order to predict the maximum ground-level concentrations to be expected from construction activities, the U.S. EPA AERMOD (version 12060) dispersion model was used.

The maximum emission rate from the construction area was modelled based on a g/m^2s basis. Worst-case emissions were modelled using five years of representative meteorological data from Pearson International Airport as supplied by the Ministry of the Environment (MOE), and MOE approved topographic data. The model also considered the geometries of the emission source in predicting ground-level concentrations.

A nested receptor grid was modelled around the construction area, as outlined in the MOE's "Air Dispersion Modelling Guide for Ontario", to determine impacts to the surrounding area (MOE, 2009). Note that the AERMOD model does not consider that buildings can physically block a contaminant plume, which can result in a greater spread of contaminants in the modelled results. Additionally, for area sources (such as open-pit construction) the downwash of a contaminant plume which can be generated by buildings in the surrounding area is not considered by the AERMOD model.

Modelling was performed both with and without mitigation to show the improvements in ground level dust concentrations that can be achieved. Due to the large amount of dust generated during construction processes, mitigation is often required.

7.0 Mitigation

Given the inevitable nature of dust generation from construction activities, mitigation measures are often necessary to reduce off-site impacts. TSP is primarily related to visibility, and as such, these mitigation measures will help to reduce the nuisance associated with the construction activities.

This section does not cover every available method for dust suppression, but discusses some of the most common practices. These, or other approved methods for dust suppression, should be implemented as part of a site-wide best practices plan.

Along with good dust management practices, best management practices should involve activities such as:

- Providing signage with appropriate contact information for public inquiries;
- Choosing work plans which are likely to reduce dust generation (i.e. performing dust generating tasks individually as opposed to all at one time);
- Ensuring that local businesses are aware of the impacts which are likely to occur; and
- Providing adequate training to employees with respect to reducing dust generation.

Additionally, methods such as barrier construction will not reduce site-wide emissions but rather act to reduce off-site impacts of such emissions.

It is recommended that the Environment Canada "Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities" document be followed for mitigation techniques, not only for dust but for other contaminants such as CO and NO_2 as well.

7.1 Mitigation Techniques

7.1.1 Material Wetting or Chemical Suppressants

When possible, the application of water or a chemical dust suppressant has been shown to reduce particulate emissions by as much as 98%. Although this level of reduction is difficult to achieve, it is not unreasonable to expect a reduction of around 75%, achievable by doubling the moisture content of material being processed. This method will be especially effective during material processing and transfer. Additionally, the U.S. EPA document AP-42 chapter 13.2.4 suggests that with the addition of surfactants to the watering processes, dust suppression can be expected to be around 90%.

7.1.2 Construction of Barriers

Wind will increase the emissions from material processing as well as fugitive emissions from exposed land. A simple method to reduce the suspension of particulates is the construction of a wind barrier around the construction zone. This method may also decrease off-site concentrations by increasing the initial release height of the contaminant plume.

7.1.3 Limiting Exposed Areas

Any exposed surface can act as a potential source of dust. Therefore, limiting the extent of unpaved area or providing temporary covering for areas which are expected to generate high quantities of dust (such as material stockpiles) may help reduce off-site concentrations.

7.1.4 Equipment Washing

On-site equipment has the potential to act as an easy transport method for dust to be released off-site. Washing vehicles and equipment before leaving the construction site, as well as watering loads in haul trucks, can act as an economical way to reduce the concentration of suspended particulates.

7.2 Overall Reductions Expected

Based on the discussed mitigation techniques, reductions of particulate emissions of up to 98% can be achieved. The U.S. EPA AP-42 chapter 13.2.2 suggests that by doubling the surface moisture content, 75% control efficiency can be achieved. Furthermore, increasing surface moisture content five-fold can achieve a 95% control efficiency; although less efficient than doubling the moisture content, in some cases this additional control efficiency will be beneficial. Due to the inevitable nature of construction, in order to meet high efficiency reduction targets (i.e. 98%) at nearby receptors large barriers will likely be required.

Based on these recommendations an emission reduction target of 75% was applied in this assessment in order to estimate an achievable reduction in TSP concentrations with the inclusion of mitigation. It should be noted that this reduction was not applied to the construction vehicle tailpipe emissions as watering will not have any impact on these sources.

8.0 Results

Results of the dispersion modelling are presented below. Modelling was performed both with and without mitigation to show the improvements in ground level dust concentrations that can be achieved. Due to the large amount of dust generated during construction processes, mitigation is often required. Common mitigation strategies are presented in **Section 6.1** and based on these techniques, a conservative 75% reduction target was applied to predict results with mitigation in place. **It should be understood that the maximum predicted TSP concentrations were assessed using conservative assumptions and that for the majority of time experienced TSP levels off-site will be substantially less than those presented in this report. In fact, predicted maximum ground level concentrations may have only occured one day over the five years modelled.** Note that the results presented in this assessment are based on the highest concentrations predicted by the dispersion modelling and do not take into account any exclusions as allowed by the Ministry of the Envrionment.

A summary of the maximum predicted TSP concentration at the worst-case sensitive receptor based on a 24-hour averaging period with and without mitigation is presented in **Table 4**. Modelling results are presented visually in **Figure 3** and **Figure 4**.

Table 4: Maximum Predicted 24-hour TSP Concentrations

Location	Pre-Mitigation (μg/m^3)	75% Mitigation (μg/m^3)	Percent Reduction
Residence	35,509	16,342	54%

Figure 3: Unmitigated 24-hour TSP Results

Figure 4: 75% Mitigated 24-hour TSP Results

9.0 Conclusions & Recommendations

With any major construction project, at times dust concentrations are expected to be high for visibility in the surrounding area. As such, mitigation is recommended in most cases to reduce the nuisance associated with construction activities. The unmitigated results presented are for the worst-case emission rates occurring throughout the construction process, therefore lower ground-level concentrations can be expected during other phases of construction.

As can be seen in the results in **Section 7**, applying a mitigation strategy at a 75% reduction target will greatly reduce the construction impacts. Therefore, it is recommended that a dust management plan be developed by the contractor including the mitigation techniques outlined in **Section 6**.

It is important to recognize that the 75% reduction target is a suggested typical target often achieved through dust mitigation techniques; actual reduction levels will depend on which mitigation procedures are performed as well as several on-site conditions.

Different levels of mitigation may be required at different construction phases. The focus of the mitigation plan is to reduce the dust emissions from the material processing activities, the major contributor to total dust emissions, and not to reduce vehicle emissions.

It is recommended that the Environment Canada "Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities" document be followed for mitigation techniques, not only for dust but for other pollutants such as carbon monoxide and oxides of nitrogen as well (Environment Canada, 2005).

It should be noted that the final design for the maintenance and storage facility may require provincial approval in the form of an Environmental Compliance Approval (ECA) or and Environmental Activity and Sector Registry (EASR) submission for both air and noise.

10.0 References

Environment Canada. (2005). *Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities.* Environment Canada, Transboundary Issues Branch

Environment Canada. (2009). *Pits and Quarries Guidance*. Environemnt Canada, National Pollutant Release Inventory.

Golder Associates. (2011). *Geotechnical and Hydrogeological Investigation, Ottawa Light Rail Transit (OLRT).*

Ontario Publication PIBS # 5165e02, O. P. (2009). *Air Dispersion Modelling Guideline for Ontario.* Ontario Ministry of the Environment.

Ontario Publication 6570e. (2008). *Ontario's Ambient Air Quality Criteria.* Standards Development Branch, Ontario Ministry of the Environment.

Ontario Regulation 833, O. r. (2010). *Occupational Exposure Limits for Ontario Workplaces - Time Weighted Average.* Ontario Ministry of Labour.

Road Construction . (n.d.). Retrieved September 2011, from Caterpillar: http://www.cat.com/heavy-construction/products-and-applications/road-construction

US Environmental Protection Agency, Emissions Factors & AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Source